EXPLANATION

4p 4m
3-4p
3p 2-3c
2p 2c 2n
1u 1s 1g 1b 1a

4-Moderate to severe—Areas of medium to high susceptibility to landsliding. Lithology is mainly clay and minor sand. Slopes are moderate to steep. Includes moderate to large numbers of recently active landslides along drainages, especially in southwestern and east-central parts (see figures 3, 4, and 6)

3-Low to moderate—Areas of low to medium susceptibility to landsliding. Lithology is mainly clay with minor sand. Slopes are gentle to moderate. Includes sparse to moderate numbers of recently active landslides that seldom remain visible in the densely developed northern part of the county

2-Very low to low—Areas of slight to low susceptibility to landsliding. Lithology is mainly sand with minor clay and gravel. Slopes are gentle to moderate. Includes generally very few small landslides

1-Nil to very low—Areas of non-existent to slight susceptibility to landsliding. Lithology includes metamorphic rocks, gravel, sand, and clay. Slopes are nil to steep. Includes infrequent small stream-bank failures

p-Potomac Group
m-Marlboro Clay, locally includes younger units (extreme southwest border)
c-Calvert Formation, locally includes Nanjemoy Formation
n-Nanjemoy Formation
u-Upland deposits
s-Tidal marsh and river terrace deposits, includes river alluvium
g-Gneiss and schist
b-Monmouth and (or) Brightseat Formations
a-Aquia Formation, locally includes Monmouth Formation (Fort Washington area)

● (2) Location of photographs. Figures 1, 2, and 5 are shown on the large map; figures 7 and 8 are shown on figure 6

Locations of figures 3, 4, and 6

Index to U.S. Geological Survey 7.5-minute topographic quadrangles covering Prince Georges County and vicinity.

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Figure 1.--Reconstructed completely stabilized slope behind Bladensburg High School. Lower slope is in clay-rich part of the Potomac Group. Sandy soil dominates upper slope.

Figure 2.--Slow continuous failure of retaining wall between apartment building and Henson Creek along Potomac Group clay slope

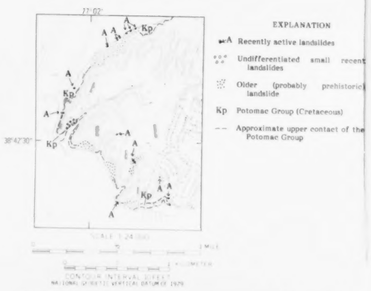

Figure 3.--The Fort Washington area showing recent and old landslides in Potomac Group and younger sediments. Geology slightly modified from Glaser (1978). Base from U.S. Geological Survey, Mount Vernon quadrangle, 1966, (photorevised 1980).

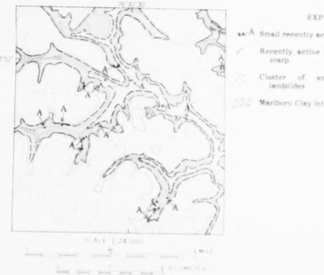

Figure 4.--Recent landslides in the Marlboro Clay 7 km northeast of Upper Marlboro. Geology slightly modified from Glaser (1984). Base from U.S. Geological Survey, Bristol quadrangle, 1957 (photorevised 1979).

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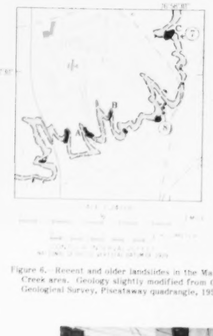

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Figure 7.--Backyard above head scarp and Marlboro Clay, Chalfont Avenue, Piscataway Creek area.

Figure 8.--Backyard with fill placed on Marlboro Clay, Taylor Avenue, Piscataway Creek area.

INTRODUCTION

This map shows landslide susceptibility based on a numerical system indicating relative degree of slide proneness. It not only delineates areas where slope stability problems are serious, but also areas where the risk of slope failure is small. The map should enable users to make a rapid, generalized evaluation of the potential for mass movement. Planners, engineers, soil scientists, geologists, university faculty, and elected officials should find it useful in the assessment of slope hazards for county-wide analyses. This map is an outgrowth of a state map at a scale of 1:500,000 that shows landslide susceptibility (Pomeroy, 1988). The map is generalized because of the 1:62,500 scale. Variations in slope sensitivity may occur at any specific point within a unit. Therefore, the map is unsuitable for actual site selection where detailed geological and/or soil engineering investigations would be appropriate.

Prince Georges County was identified during the state-wide investigation as the county with the most serious slope-stability problems. Census figures (1985) indicate that this county, which adjoins Washington, D.C., is the most highly populated in Maryland, and is undergoing additional development. The county lies almost entirely in the Coastal Plain Province. Only in the extreme northern part of the county do gneiss and schist of the Piedmont Province crop out. The Coastal Plain stratigraphic units contain clay, silt, sand, and gravel (table 1).

The county adopted grading ordinance controls and inspection enforcement in 1971 that have proven to be effective in reducing landslide problems (Prince Georges County, 1978; Osbansky and Rogers, 1967). A vast majority of known slides in the county have resulted from construction prior to 1971.

All gravitationally induced earth movements downslope are herein considered landslides, with the exception of slow, ubiquitous creep. The term "landslide" as used here is synonymous with "mass movement" and "slope movement". "Landslide" is widely used as an all inclusive term for almost all types of slope movements including some that involve little or no true sliding (Varnes, 1978, p. 11). The term includes falls, topples, slides (rotational and translational), flows, and complex forms (Varnes, 1978, fig. 2.1). "Susceptibility" to landsliding is defined as the probable degree of response of the stratigraphic units and their derivative soils to natural events or to artificial slope modifications.

For additional reading regarding the geology, soils, and slope stability of Prince Georges County and adjacent areas, the user of this map is referred to Froelich and others (1980), Heck (1977), Kirby and others (1967), Obermeier (1979), Obermeier and others (1984), Obermeier and Langer (1986), and Reed and Obermeier (1982).

METHOD OF COMPILATION

The map uses a ranking system ranging from 1 (nil to very low susceptibility) to 4 (moderate to severe susceptibility). The susceptibility categories are largely subjective based primarily on my field observations and utilization of pertinent published and unpublished data.

Field investigations, which were conducted mainly during the spring months in 1985 and 1986, involved about 30 days of traverses and reality observations. In order to gain a better understanding of the geologic environment and slope-failure processes, most of the traverses were directed to the eastern and southwestern parts of the county where the problems are more clearly defined. The availability of recent (1988) large-scale aerial photographs (scale: 1:12,000 or 1 inch=1,000 feet) with stereoscopic coverage facilitated this mapping. Aerial photographs were examined at the Maryland-National Capital Park and Planning Commission office at Upper Marlboro. Nearly 900 aerial photographs cover the county at that scale. Earlier aerial photographs were scrutinized for selected areas.

Supplementing the field investigations were discussions with the Maryland-National Capital Park and Planning Commission, the Prince Georges County Department of Licenses and Permits, the Maryland Geological Survey, the Maryland State Highway Administration, the U.S. Soil Conservation Service, and Woodward-Clyde Consultants, Rockville, Md. Ronald E. Smith (Woodward-Clyde Consultants) was particularly helpful.

The three most significant (and interrelated) natural-cause factors that contribute to landsliding are precipitation, slope, and the nature of the geologic unit (mainly lithology but also structural features such as jointing). Of these factors, lithology is the most useful factor in the compilation of a map at this scale.

The geologic map of Prince Georges County (Hack, 1977) was used in the compilation of the landslide susceptibility map except for areas north, northeast, and east of Upper Marlboro, west of lower Tinker Creek, and both north and south of the mouth of Piscataway Creek. More recent mapping (Glaser, 1978, 1981, 1984) was used for compilation in these slide-prone areas.

GEOLOGY AND ITS RELATIONSHIP TO LANDSLIDING

Most of the county is underlain by sand, clay, and gravel of Cretaceous to Quaternary age. The widespread Potomac Group crops and the more areally restricted Marlboro Clay underlie the major slide-prone areas. Relatively small numbers of slides have occurred in the Calvert Formation over its wide area of outcrop. Of lesser importance to slope failure are the Monmouth, Brightseat, Aquia, and Nanjemoy Formations, and the upland deposits. The user of this map, however, should bear in mind the effect on overlying and underlying units adjacent to a slide-prone unit. For example, upland deposits (above the Potomac Group) or the Aquia and Nanjemoy Formations (below and above the Marlboro Clay, respectively) are commonly affected in mass movement. Creep is locally pronounced along steep slopes underlain by gneiss and schist, but no ground breakage was seen.

Potomac Group

The Potomac Group crops out in a wide belt in the northern part of

Calvert Formation

The Calvert Formation crops out over a wide area in the central and southern parts of the county, but the incidence of recent landsliding is low. However, landslides have taken place in residential subdivisions northeast and west of Andrews Air Force Base within the upper Henson Creek watershed, as well as east of Andrews. Several documented landslides cited by Prince Georges County (1978) but not identified as to underlying geologic unit have originated in the Calvert Formation.

Slopes above the drainage south of Old Colony Drive in the Marlboro area have been modified and show a few recent slides above creek level. The slippage horizon is believed to be a clay bed. Hack (1977) states that layers of swelling clay in areas south of Upper Marlboro. Reconnaissance investigation indicates that clay interbeds underlie a wider area and include slopes west of Upper Marlboro extending to the District of Columbia line.

HIGH PRECIPITATION PERIODS AND THEIR RELATION TO LANDSLIDING

Precipitation is a major factor in landslide initiation. Records for the 27 year period from 1960 to 1986 at Beltsville and Upper Marlboro (fig. 9) show that the 1960's were below normal in precipitation, whereas the 1970s were unusually wet generally due to four tropical storm events which followed above-normal precipitation in June, July, and August. The high 1983 precipitation was concentrated during the spring and late fall months. Landslide activity was intense during the 1970s throughout the Coastal Plain.

Climatic factors played a role in the toppling failure of the previously discussed Greenbelt excavation in December 1982. It had been much wetter and milder than normal, while December was drier and colder than usual (National Oceanic and Atmospheric Administration, 1968). Withington (1961) estimates that the ground was frozen to a depth of about 1 m. Melting snow flowed into a joint located about 0.3 m from the edge of the excavation. The frozen clay did not allow for any deep penetration of water, whereupon hydrostatic pressure formed the joint surface apart resulting in a toppling of the unsupported clay mass. Because of the December dryness, desiccation cracks enhanced the percolation of meltwater.

Copious rainfall in June 1972 attributable to tropical storm Agnes must have generated significant numbers of slides in Prince Georges County, but very little documentation is available relating landslide activity to that storm.

Slope problems in the Marlboro Clay of southwestern Prince Georges County north of Piscataway Creek and east of the Indian Head Highway (Md. Route 210) intensified in 1975. This followed above-normal precipitation during the summer months and copious rainfall during a 5-day period from September 23 to September 27 caused by tropical storm Eloise (figs. 6, 7, 8). Over 8.0 inches (23 cm) fell at National Airport and nearly 11.5 inches (29 cm) fell at Upper Marlboro during the period. As a result of recharge from these abnormally heavy late September rains, water in some wells were at or near its highest level for the end of September in at least 20 years (U.S. Geological Survey, 1976). A letter written in October from the President of the Forest Knolls Citizens' Association to the Chairman, Washington Suburban Sanitary Commission (Prince Georges County, 1975) referred to the slope problems caused by the rain that affected nearly 10 percent of the 360 houses in the subdivision. The Chalfont Avenue slide (fig. 7) moved significantly following this period (Woodward-Clyde Consultants, 1976). Another slide, which was pictured by the Washington Post on August 16, 1979, is behind Taylor Avenue in the same subdivision and developed to its present extent during 1975 (fig. 8).

A relatively high 5-month total rainfall beginning in June 1979 was accentuated by tropical storm David in early September. Although precipitation from this storm was less than half of that from tropical storm Eloise and produced significant rainfall only during a one-day period compared to five days for Eloise, record high runoff peaks were recorded at several gaging stations in the Baltimore and southern Maryland areas (U.S. Geological Survey, 1980). The gaging station less than 1 km away from the residential area (Chalfont and Taylor Avenue) severely affected by the 1975 storm was one of these stations. Documentation pertaining to property owner calls concerning slope problems to Prince Georges County organizations (Maryland-National Capital Park and Planning Commission and Prince Georges County Department of Licenses and Permits) is lacking. Rainfall was intense only during the one-day period that the storm affected Prince Georges County, and apparently the high runoff values precluded any significant rise in the water table. Nevertheless, an examination of 1:12,000 aerial photography taken in March 1977 and March 1980 show the development of head scarps in the 1980 photography about tributary drainages north of Piscataway Creek (fig. 6, A and B, p. 3). These two landslides had been identified in the field prior to the aerial photograph inspection.

Heavy precipitation in the spring and fall of 1983 must have generated significant numbers of landslides in Prince Georges County, but documentation is lacking. As far as can be determined, landslide activity since 1984 has been negligible in the county. Very few fresh scars denoting recent activity were seen during the investigation. The very low incidence of new slides relates directly to the below-normal precipitation record for 1984-1986 (fig. 9).

SUMMARY

Geologic factors (including lithology and joints) and precipitation are major elements in the initiation of landslides in Prince Georges County. The Potomac Group in the northern and extreme western parts and the Marlboro Clay in the southwestern and east-central parts are the most slide-prone geologic units. The only other unit from which low to moderate numbers of landslides have taken place is the Calvert

EXPLANATION

3-4p

2-3c

2c 2n

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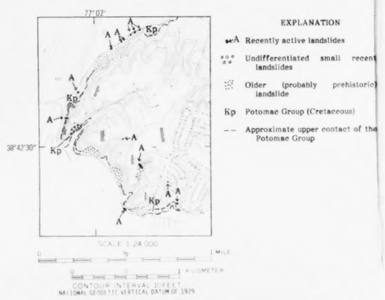

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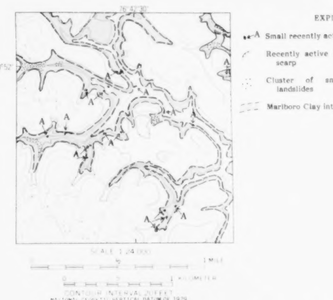

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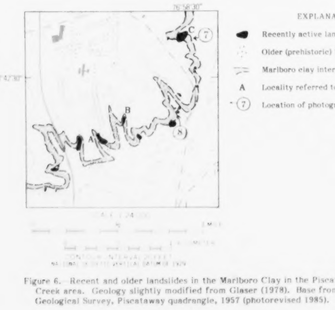

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Potomac Group

The Potomac Group crops out in a wide belt in the northern part of Prince Georges County and extends southwestward along the Maryland-District of Columbia border to the Potomac River and its tributaries in the extreme western part of the county. Problems related to slope stability are most numerous in areas underlain by the red to variegated clays of the non-marine Potomac Group. These areas are denoted on the map by 3p, 3-4p, and 4p. Interlayed with the multi-colored clays are beds of sand and the north-facing aspect of the slope, which is slow to dry out, and roof downspouts that drain downslope (to the north) behind the houses rather than to the front (street).

Calvert Formation

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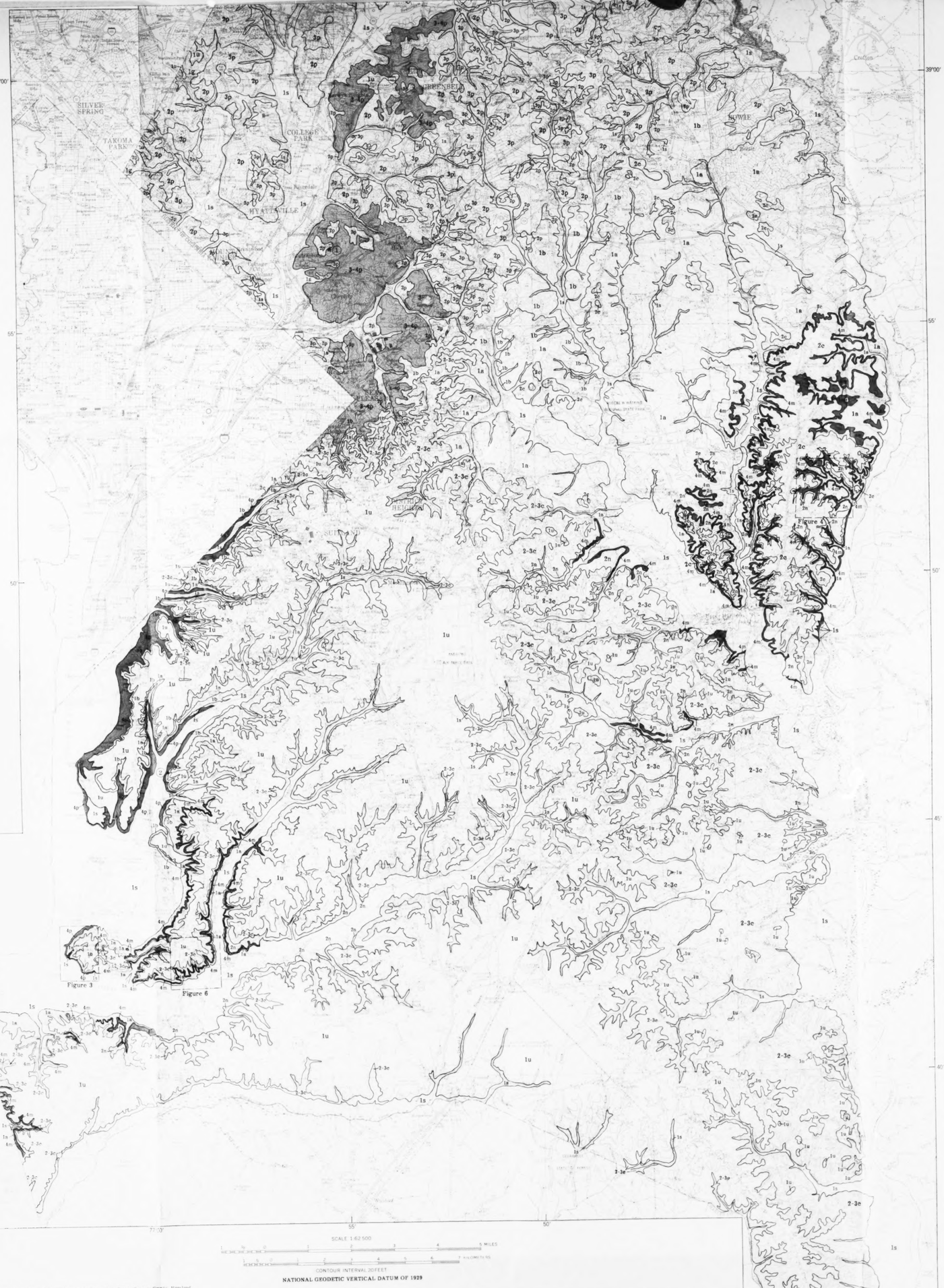
SUMMARY

Geologic factors (including lithology and joints) and precipitation are major elements in the initiation of landslides in Prince Georges County. The Potomac Group in the northern and extreme western parts and the Marlboro Clay in the southwestern and east-central parts are the most slide-prone geologic units. The only other unit from which low to moderate numbers of landslides have taken place is the Calvert Formation. In the past 25 years significant landsliding took place mostly during the 1970s largely due to the impact of tropical storms. Recent years have seen a dearth of fresh slide scars because of below-normal precipitation.

REFERENCES CITED

Index to U.S. Geological Survey 7.5-minute topographic quadrangles covering Prince Georges County and vicinity.

County index map of Maryland showing the location of Prince Georges County



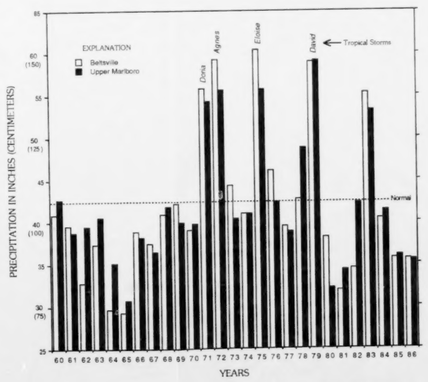
Base from Maryland Geological Survey Prince Georges County, 1961 (revised 1969)

Table 1.--Correlation of geologic and landslide susceptibility units in Prince Georges County, Maryland

[Symbol used: —, not applicable]

System	Series	Group	Geologic Map Unit (modified from Hack, 1977)	Thickness in feet (meters)	Lithologic character	Landslide Susceptibility Unit (See Explanation for meaning of symbols)
Quaternary	Holocene to Pleistocene		Tidal marsh deposits		Water-saturated silt, sand, and muck	1s
			River alluvium River terrace deposits	0-40 (12) 0-50 (15)	Clay, silt, sand, and gravel Gravelly and sandy material generally overlain by sandy to silty clay loam	
	Pliocene		Upland deposits (informal name of unit)	0-50 (15)	Gravel and sand grading upward to loam and silt loam	1u
Tertiary	Miocene	Chesapeake	Calvert Formation	0-150 (46)	Fine to very fine sand, silt, and clay, light colored and thinly stratified	2-3c, 2c
	Eocene	Pamunkey	Nanjemoy Formation	0-40 (24)	Clay and greenish-gray clayey sand and sandy clay of marine origin, containing glauconite	2n
			Marlboro Clay[1]	0-36 (11)	Pale red and brown silty clay of marine origin, thinly laminated to massive	4m
	Paleocene		Aquia Formation	0-200 (60)	Greenish-gray marine sand	1a
			Brightseat Formation	0-20 (6)	Dark green to gray-green glauconitic sand	1b
Cretaceous	Upper Cretaceous	-----	Monmouth Formation	0-40 (12)	Dark greenish-gray to black sand and silt	1b
	Lower Cretaceous	Potomac	Patapsco Formation	0-1,000 (300+) for Group	Red to variegated and white clay, minor sand	3p, 4p, 3-4p
			Patuxent Formation		Medium to coarse sand, sandy clay and gravel	2p
			Undifferentiated		Gravel, sand, and clay	----
Lower Paleozoic to Proterozoic			Undifferentiated metamorphic rocks	-----	Gneiss and schist	1g

[1]Pollen and dinoflagellate data in Virginia suggest a very late Paleocene or a very early Eocene age assignment (Ward, 1985)



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MAP SHOWING LANDSLIDE SUSCEPTIBILITY IN PRINCE GEORGES COUNTY, MARYLAND

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Figure 5.--Earthflow in the Marlboro Clay 4 km east-northeast of Upper Marlboro. A, head scarp.

Figure 7.--Backyard above head scarp and Marlboro Clay, Chalfont Avenue, Piscataway Creek area.

Figure 4.--Recent landslides in the Marlboro Clay 7 km northeast of U. Marlboro. Geology slightly modified from Glaser (1984). Base from Geological Survey, Bristol quadrangle, 1957 (photorevised 1979).

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INTRODUCTION

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Prince Georges County was identified during the state-wide investigation as the county with the most serious slope-stability problems. Census figures (1985) indicate that this county, which adjoins Washington, D.C., is the most highly populated in Maryland, and is undergoing additional development. The county lies almost entirely in the Coastal Plain Province. Only in the extreme northern part of the county do gneiss and schist of the Piedmont Province crop out. The Coastal Plain stratigraphic units contain clay, silt, sand, and gravel (table 1).

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All gravitationally induced earth movements downslope are herein considered landslides, with the exception of slow, ubiquitous creep. The term "landslide" as used here is synonomous with "mass movement" and "slope movement". "Landslide" is widely used as an all-inclusive term for almost all types of slope movements including some that involve little or no true sliding (Varnes, 1978, p. 11). The term includes falls, topples, slides (rotational and translational), flows, and complex forms (Varnes, 1978, fig. 2.1). "Susceptibility" to landsliding is defined as the probable degree of response of the stratigraphic units and their derivative soils to natural events or to artificial slope modifications.

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GEOLOGY AND ITS RELATIONSHIP TO LANDSLIDING

Most of the county is underlain by sand, clay, and gravel of Cretaceous to Quaternary age. The widespread Potomac Group clays and the more areally restricted Marlboro Clay underlie the major slide-prone areas. Relatively small numbers of slides have occurred in the Calvert Formation over its wide area of outcrop. Of lesser importance is slope failure are the Monmouth, Brightseat, Aquia, and Nanjemoy Formations, and the upland deposits. The user of this map, however, should bear in mind the effect on overlying and underlying units adjacent to a slide-prone unit. For example, upland deposits (above the Potomac Group) or the Aquia and Nanjemoy Formations (below and above the Marlboro Clay, respectively) are commonly affected in mass movement. Creep is locally pronounced along steep slopes underlain by gneiss and schist, but no ground breakage was seen.

Potomac Group

The Potomac Group crops out in a wide belt in the northern part of Prince Georges County and extends southwestward along the Maryland-District of Columbia border to the Potomac River and its tributaries in the extreme western part of the county. Problems related to slope stability are most numerous in areas underlain by the red to variegated clays of the non-marine Potomac Group. These areas are denoted on the map as 3p, 3-4p, and 4p. Interlayed with the multi-colored clays are beds of sand and gravel. Of lesser importance to the slope stability problem are the dominantly sand and gravel parts of the Potomac Group which contain minor clay beds (2p). The Potomac Group is variable within short distances both vertically and horizontally because of its non-marine deposition. Its thickness in the county exceeds 300 m. The depositional environment was fluvial, consisting of channel and overbank deposits (Patuxent and Patapsco Formations, respectively). The heterogenity of this Group makes landslide hazard zonation difficult.

In northern Prince Georges County most of the slide-prone areas occur in a 6- to 10-kilometer-wide belt extending from Seat Pleasant northward to the Greenbelt area and include Cheverly, Bladensburg (Fig. 1), Landover Hills, and New Carrollton. Slopes show instability along drainages in the proximity of the District of Columbia-Maryland border southwest of Seat Pleasant. To the south, slopes bordering the Potomac River and tributaries such as Broad and Henson Creeks are slide-prone (fig. 2). The shoreline at Fort Washington is rimmed by Potomac Group clays (fig. 3) that have affected the integrity of the installation itself (Woodward-Clyde Consultants, 1978).

The paucity of recent landslide scars in the Potomac Group in Prince Georges County is mainly due to the dryness of the 1980's. In this densely developing area, landslide damage is commonly mitigated soon after it occurs because of population pressures and demands for fast repair of damaged transportation routes. New construction for both residential subdivisions and roads in northern Prince Georges County is commonly restricted because of a lack of available space.

The costliest slope failure in terms of human life took place as a toppling failure in red clay (Patapsco Formation) at a foundation excavation at the Beltway Plaza shopping center at Greenbelt (Withington, 1964). Five were killed and eleven were injured at the construction site in December 1962. Relief joints in the clay had opened during excavation because of desiccation and lack of lateral support. Melting snow filled relief joints resulting in high pore-water pressure and the toppling of a 12 m long, 4.5 m high, and 0.3 m thick unsupported clay slab.

Marlboro Clay

The Marlboro Clay crops out in two areas of the county--the east-central part surrounding Upper Marlboro but mainly to the north, northeast, and east (figs. 4 and 5), and the southwestern part of the county along the slopes bordering the lower sections of Tinker and Piscataway Creeks and the west side of the upland area between Tinker Creek and the Potomac River. Commonly, overlying and underlying slopes are affected by movement which originates within the weathered part of the Marlboro Clay. Therefore, as previously mentioned, structures erected on either the Aquia or Nanjemoy Formations might be subject to the effects of slope movements from the adjacent Marlboro Clay.

In two localities north of Piscataway Creek (fig. 6, A and B), slides originating at drainage level in Marlboro Clay have moved upslope with headward margins in the weathered part of the overlying Calvert Formation. At locality C (fig. 6), what started as a series of small minor earth flows slightly above creek level in Marlboro Clay in the early 1970s (Woodward-Clyde Consultants, 1976) developed into larger movements with head scarps in upland deposits near the hilltop in 1975 (fig. 7). Smaller but equally menacing earth flows plagued a part of another subdivision (fig. 8).

A combination of reasons accounts for the large movement at locality C. Older drainages were disrupted as extensive slope modification took place. The filling of these channels probably contributed to a rise in ground-water levels. Cores by Woodward-Clyde Consultants (1976) showed that the Marlboro Clay dips to the north and a perched water table exists at the top of the Marlboro Clay. Also contributing to the slope problem is the north-facing aspect of the slope, which is slow to dry out, and roof downspouts that drain downslope (to the north) behind the houses rather than to the front (street).

Calvert Formation

The Calvert Formation crops out over a wide area in the central and southern parts of the county, but the incidence of recent landsliding is low. However, landslides have taken place in residential subdivisions northwest and west of Andrews Air Force Base within the upper Henson Creek watershed, as well as east of Andrews. Several documented landslides cited by Prince Georges County (1978) but not identified as to underlying geologic unit have originated in the Calvert Formation.

Slopes above the drainage south of Old Colony Drive in the Marlton area have been modified and show a few recent slides above creek level; the slippage horizon is believed to be a clay bed. Hack (1977) cites thin layers of swelling clay in areas south of Upper Marlboro. The present investigation indicates that clay interbeds underlie a wider area and include slopes west of Upper Marlboro extending to the District of Columbia line.

HIGH PRECIPITATION PERIODS AND THEIR RELATION TO LANDSLIDING

Precipitation is a major factor in landslide initiation. Records for the 27 year period from 1960 to 1986 at Beltsville and Upper Marlboro (fig. 9) show that the 1960's were below normal in precipitation, whereas the 1970s were unusually wet generally due to four tropical storms (two of which followed above-normal precipitation in June, July, and August). The high 1983 precipitation was concentrated during the spring and late fall months. Landslide activity was intense during the 1970s throughout the Coastal Plain.

Climatic factors played a role in the toppling failure of the previously discussed Greenbelt excavation in December 1962. November had been much wetter and colder than normal, while December was drier and colder than usual (National Oceanic and Atmospheric Administration, 1968). Withington (1963) estimates that the ground was frozen to a depth of about 1 m. Melting snow flowed into a joint located about 0.3 m from the edge of the excavation. The frozen clay did not allow for any deep penetration of water, whereupon hydrostatic pressure forced the joint surface apart resulting in a toppling of the unsupported clay slab. Because of the December dryness, desiccation cracks enhanced the percolation of meltwater.

Copious rainfall in June 1972 attributable to tropical storm Agnes must have generated significant numbers of slides in Prince Georges County, but very little documentation is available relating landslide activity to that storm.

Slope problems in the Marlboro Clay of southwestern Prince Georges County north of Piscataway Creek and east of the Indian Head Highway (Md. Route 210) intensified in 1975. This followed above-normal precipitation during the summer months and copious rainfall during a 5-day period from September 23 to September 27 caused by tropical storm Eloise (figs. 6, 7, 8). Over 9.0 inches (23 cm) fell at National Airport and nearly 11.5 inches (29 cm) fell at Upper Marlboro during the period. As a result of recharge from these abnormally heavy late-September rains, water in some wells were at or near its highest level for the end of September in at least 20 years (U.S. Geological Survey, 1976). A letter written in October from the President of the Forest Knolls Citizens' Association to the Chairman, Washington Suburban Sanitary Commission (Prince Georges County, 1978) referred to the slope problems caused by the rain that affected nearly 10 percent of the 360 houses in the subdivision. The Chalfont Avenue slide (fig. 7) moved significantly following this period (Woodward-Clyde Consultants, 1976). Another slide, which was pictured by the Washington Post on August 16, 1979, is behind Taylor Avenue in the same subdivision and developed to its present extent during 1975 (fig. 8).

A relatively high 5-month total rainfall beginning in June 1979 was accentuated by tropical storm David in early September. Although precipitation from this storm was less than half of that from tropical storm Eloise and produced significant rainfall only during a one-day period compared to five days for Eloise, record high runoff peaks occurred at several gaging stations in the Baltimore and southern Maryland areas (U.S. Geological Survey, 1980). The gaging station less than 1 km away from the residential area (Chalfont and Taylor Avenue) severely affected by the 1975 storm was one of these stations. Documentation pertaining to property owner calls concerning slope problems to Prince Georges County organizations (Maryland National Capital Park and Planning Commission and Prince Georges County Department of Licenses and Permits) is lacking. Rainfall was intense only during the one-day period that the storm affected Prince Georges County, and apparently the high runoff levels precluded any significant rise in the water levels in wells. Nevertheless, examination of 1:12,096 aerial photographs taken in March 1977 and March 1980 show the development of head scarps in the 1980 photographs above tributary drainages north of Piscataway Creek (fig. 6, A and B). These two landslides had been identified in the field prior to the aerial photograph inspection.

Heavy precipitation in the spring and fall of 1983 must have generated significant numbers of landslides in Prince Georges County, but documentation is lacking. As far as can be determined, landslide activity since 1984 has been negligible in the county. Very few fresh scars of recent activity were seen during the investigation. The low incidence of new slides relates directly to the below-normal precipitation record for 1984-1986 (fig. 9).

SUMMARY

Geologic factors (including lithology and joints) and precipitation are major elements in the initiation of landslides in Prince Georges County. The Potomac Group in the northern and extreme western parts and the Marlboro Clay in the southwestern and east-central parts are the most slide-prone geologic units. The only other unit from which low to moderate numbers of landslides have taken place is the Calvert Formation. In the past 25 years significant landsliding took place mostly during the 1970s largely due to the impact of tropical storms. Recent years have seen a dearth of fresh slide scars because of below normal precipitation.

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CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Table 1.--Correlation of geologic and landslide susceptibility units in Prince Georges County, Maryland

[Symbol used: --, not applicable]

Series	Group	Geologic Map Unit (Modified from Hack, 1977)	Thickness in feet (in meters)	Lithologic character	Landslide Susceptibility Unit (See Explanation for meaning of symbols)
Holocene to Pleistocene		Tidal marsh deposits.		Water-saturated silty, silt, sand, and mark.	1s
		River alluvium. River terrace deposits.	0-40 (12) 0-50 (15)	Clay, silt, sand, and gravel. Gravelly and sandy material generally overlain by sandy to silty clay loam.	
Pliocene?		Upland deposits (ancient river deposits)	0-50 (15)	Gravel and sand grading upward to loam and silt loam	1u
Miocene	Chesapeake	Calvert Formation	0-150 (46)	Fine to very fine sand, silt, and clay, light colored and thinly stratified	2-3c, 2c
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		Marlboro Clay[2]	0-36 (11)	Pale red and brown silty clay of marine origin, thinly laminated to massive	4m
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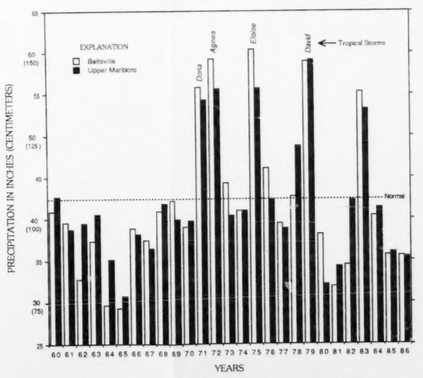

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0 1 2 3 4 5 KILOMETER
CONTOUR INTERVAL 20 FEET
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Figure 3.--The Fort Washington area showing recent and old landslides in Potomac Group and younger sediments. Geology slightly modified from Glaser (1978). Base from U.S. Geological Survey, Mount Vernon quadrangle, 1966, (photorevised 1980).

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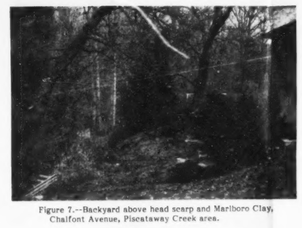

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The geologic map of Prince Georges County (Hack, 1977) was used in the compilation of the landslide susceptibility map except for areas north, northeast, and east of Upper Marlboro, west of lower Tinker Creek, and both north and south of the mouth of Piscataway Creek. More recent mapping (Glaser, 1978, 1981, 1984) was used for compilation in these slide-prone areas.

GEOLOGY AND ITS RELATIONSHIP TO LANDSLIDING

Most of the county is underlain by sand, clay, and gravel of Cretaceous to Quaternary age. The widespread Potomac Group strata and the more areally restricted Marlboro Clay underlie the major slide-prone areas. Relatively small numbers of slides have occurred in the Calvert Formation over its wide area of outcrop. Of lesser importance to slope failure are the Monmouth, Brightseat, Aquia, and Nanjemoy Formations, and the upland deposits. The user of this map, however, should bear in mind the effect on overlying and underlying units adjacent to a slide-prone unit. For example, upland deposits (above the Potomac Group) or the Aquia and Nanjemoy Formations (below and above the Marlboro Clay, respectively) are commonly affected in mass movement. Creep is locally pronounced along steep slopes underlain by gneiss and schist, but no ground breakage was seen.

Potomac Group

The Potomac Group crops out in a wide belt in the northern part of Prince Georges County and extends southwestward along the Maryland-District of Columbia border to the Potomac River and its tributaries in the extreme western part of the county. Problems related to slope stability are most numerous in areas underlain by the red to variegated clays of the non-marine Potomac Group. These areas are denoted on the map by 3p, 3-4p, and 4p. Interlayed with the multi-colored clays are beds of sand and gravel. Of lesser importance to the slope stability problems are the dominantly sand and gravel parts of the Potomac Group which contain minor clay beds (2p). The Potomac Group is variable within short distances both vertically and horizontally because of its non-marine deposition. Its thickness in the county exceeds 300 m. The depositional environment was fluvial, consisting of channel and overbank deposits (Patuxent and Patapsco Formations, respectively). The heterogenity of this Group makes landslide hazard zonation difficult.

In northern Prince Georges County most of the slide-prone areas occur in a 6- to 10-kilometer-wide belt extending from Seat Pleasant southwest to the Greenbelt area and include Cheverly, Bladensburg (fig. 1), Landover Hills, and New Carrollton. Slopes show instability along drainages in the proximity of the District of Columbia-Maryland border southwest of Seat Pleasant. To the south, slopes bordering the Potomac River and tributaries such as Broad and Henson Creeks are slide-prone (fig. 2). The shoreline at Fort Washington is rimmed by Potomac Group clays (fig. 3) that have affected the integrity of the installation itself (Woodward-Clyde Consultants, 1978).

The paucity of recent landslide scars in the Potomac Group in Prince Georges County is mainly due to the dryness of the 1980's. In this densely developing area, landslide damage is commonly mitigated soon after it occurs because of population pressures and demands for fast repair of damaged transportation routes. New construction for both residential subdivisions and roads in northern Prince Georges County is commonly restricted because of a lack of available space.

The costliest slope failure in terms of human life took place as a toppling failure in red clay (Patapsco Formation) at a foundation excavation at the Beltway Plaza shopping center at Greenbelt (Withington, 1964). Five were killed and eleven were injured at the construction site in December 1962. Relict joints in the clay had opened during excavation because of desiccation and lack of lateral support. Melting snow filled relict joints resulting in high pore-water pressure and the toppling of a 12 m long, 4.5 m high, and 0.3 m thick unsupported clay slab.

Marlboro Clay

The Marlboro Clay crops out in two areas of the county--the east-central part surrounding Upper Marlboro but mainly to the north, northeast, and east (figs. 4 and 5), and the southwestern part of the county along the slopes bordering the lower sections of Tinker and Piscataway Creeks and the west side of the upland area between lower Tinker Creek and the Potomac River. Commonly, overlying and underlying slopes are affected by movement which originates within the weathered part of the Marlboro Clay. Therefore, as previously mentioned, structures erected on either the Aquia or Nanjemoy Formations might be subject to the effects of slope movements from the adjacent Marlboro Clay.

In two localities north of Piscataway Creek (fig. 6, A and B), slides originating at drainage level in Marlboro Clay have moved upslope with headward margins in the weathered part of the overlying Calvert Formation. At locality C (fig. 6), what started as a series of small minor earth flows slightly above creek level in Marlboro Clay in the early 1970s (Woodward-Clyde Consultants, 1976) developed into larger movements with head scarps in upland deposits near the hilltop in 1975 (fig. 7). Smaller but equally menacing earth flows plagued a part of another subdivision (fig. 8).

A combination of reasons accounts for the large movement at locality C. Older drainages were disrupted as extensive slope modification took place. The filling of these channels probably contributed to a rise in ground-water levels. Cores by Woodward-Clyde Consultants (1976) showed that the Marlboro Clay dips to the north and a perched water table exists at the top of the Marlboro Clay. Also contributing to the slope problem is the north-facing aspect of the slope, which is slow to dry out, and roof downspouts that drain downslope (to the north) behind the houses rather than to the front (street).

Calvert Formation

The Calvert Formation crops out over a wide area in the central and southern parts of the county, but the incidence of recent landsliding is low. However, landslides have taken place in residential subdivisions northwest and west of Andrews Air Force Base within the upper Henson Creek watershed, as well as east of Andrews. Several documented landslides cited by Prince Georges County (1978) but not identified as to underlying geologic unit have originated in the Calvert Formation.

Slopes above the drainage south of Old Colony Drive in the Marlton area have been modified and show a few recent slides above creek level; the slippage horizon is believed to be a clay bed. Hack (1977) cites thin layers of swelling clay in areas south of Upper Marlboro. The present investigation indicates that clay interbeds underlie a wider area and include slopes west of Upper Marlboro extending to the District of Columbia line.

HIGH PRECIPITATION PERIODS AND THEIR RELATION TO LANDSLIDING

Precipitation is a major factor in landslide initiation. Records for the 27-year period from 1960 to 1986 at Beltsville and Upper Marlboro (fig. 9) show that the 1960's were below normal in precipitation, whereas the 1970s were unusually wet generally due to four tropical storms (two of which followed above normal precipitation in June, July, and August). The high 1983 precipitation was concentrated during the spring and late fall months. Landslide activity was intense during the 1970s throughout the Coastal Plain.

Climatic factors played a role in the toppling failure of the previously discussed Greenbelt excavation in December 1962. November had been much wetter and colder than normal, while December was drier and colder than usual (National Oceanic and Atmospheric Administration, 1968). Withington (1963) estimates that the ground was frozen to a depth of about 1 m. Melting snow flowed into a joint located about 0.3 m from the edge of the excavation. The frozen clay did not allow for any deep penetration of water, whereupon hydrostatic pressure forced the joint surface apart resulting in a toppling of the unsupported clay slab. Because of the December dryness, desiccation cracks enhanced the percolation of meltwater.

Copious rainfall in June 1972 attributable to tropical storm Agnes must have generated significant numbers of slides in Prince Georges County, but very little documentation is available relating landslide activity to that storm.

Slope problems in the Marlboro Clay of southwestern Prince Georges County north of Piscataway Creek and east of the Indian Head Highway (Md. Route 210) intensified in 1975. This followed above-normal precipitation during the summer months and copious rainfall during a 5-day period from September 23 to September 27 caused by tropical storm Eloise (figs. 6, 7, 8). Over 9.0 inches (23 cm) fell at National Airport and nearly 11.5 inches (29 cm) fell at Upper Marlboro during the period. As a result of recharge from these abnormally heavy late-September rains, water in some wells were at or near its highest level for the end of September in at least 20 years (U.S. Geological Survey, 1976). A letter written in October from the President of the Forest Knolls Citizens' Association to the Chairman, Washington Suburban Sanitary Commission (Prince Georges County, 1978) referred to the slope problems caused by the rain that affected nearly 10 percent of the 360 houses in the subdivision. The Chalfont Avenue slide (fig. 7) moved significantly following this period (Woodward-Clyde Consultants, 1976). Another slide, which was pictured by the Washington Post on August 16, 1979, is behind Taylor Avenue in the same subdivision and developed to its present extent during 1975 (fig. 8).

A relatively high 5-month total rainfall beginning in June 1979 was accentuated by tropical storm David in early September. Although precipitation from this storm was less than half of that from tropical storm Eloise and produced significant rainfall only during a one-day period compared to five days for Eloise, record high runoff peaks occurred at several gaging stations in the Baltimore and southern Maryland areas (U.S. Geological Survey, 1980). The gaging station less than 1 km away from the residential area (Chalfont and Taylor Avenue) severely affected by the 1975 storm was one of these stations. Documentation pertaining to property owner suits concerning slope problems to Prince Georges County organizations (Maryland-National Capital Park and Planning Commission and Prince Georges County Department of Licenses and Permits) is lacking. Rainfall was intense only during the one-day period that the storm affected Prince Georges County, and apparently the high runoff levels precluded any significant rise in the water table. Nevertheless, examination of 1:12,000 aerial photography taken in March 1977 and in March 1980 show the development of head scarps in the 1980 photograph above tributary drainages north of Piscataway Creek (fig. 6, A and B). These two landslides had been identified in the field prior to the aerial photograph inspection.

Heavy precipitation in the spring and fall of 1983 must have generated significant numbers of landslides in Prince Georges County, but documentation is lacking. As far as can be determined, landslide activity since 1984 has been negligible in the county. Very few fresh scars denoting recent activity were seen during the investigation. The very low incidence of new slides relates directly to the below-normal precipitation record for 1984-1986 (fig. 9).

SUMMARY

Geologic factors (including lithology and joints) and precipitation are major elements in the initiation of landslides in Prince Georges County. The Potomac Group in the northern and extreme western parts and the Marlboro Clay in the southwestern and east-central parts are the most slide-prone geologic units. The only other unit from which low to moderate numbers of landslides have taken place is the Calvert Formation. In the past 25 years significant landsliding took place mostly during the 1970s largely due to the impact of tropical storms. Recent years have seen a dearth of fresh slide scars because of below-normal precipitation.

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MAP SHOWING LANDSLIDE SUSCEPTIBILITY IN PRINCE GEORGES COUNTY, MARYLAND

By John S. Pomeroy

MISCELLANEOUS FIELD STUDIES MAP
Published by the U.S. Geological Survey, 1989

POMEROY—LANDSLIDE SUSCEPTIBILITY, PRINCE GEORGES COUNTY, MD. 1:62,500 MAP MF-2051